# *HOUSTON TOWNHOMES & AFFORDABILITY*

Relative townhome prices 2005-2018

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## Introduction

Houston is often held up as the example of the un-zoned American city, with the implication being that Houston's land use is altogether unregulated and the city's form is the purest reflection of market forces in any major U.S. city (Lewyn, 2005). While it is true that Houston has no zoning code and that land is developed with fewer use restrictions than most places, it is far from unregulated. Houston has many regulations that apply to form typologies rather than land areas (Lewyn, 2005), and there is a raft of regulations surrounding things such as parking requirements, street widths, and lot size among other things.

Perhaps the strongest example of Houston's zoning like regulations effecting the built environment is minimum lot size requirements. Houston's housing market is dominated by single family detached houses, and this is not accidental. Prior to 1998, minimum lot sizes for single family homes were 5,000 square feet of land, while townhouses were required to occupy at least 2,250 square feet of land (Lewyn, 2005). While the requirement is less than for single family homes, it is much larger than in peer cities. For example, in Dallas, townhomes can be as small at 647sqft. of land, 560sqft. in Phoenix, and 390sqft. in Toronto, Canada (Lewyn, 2005). This essentially made townhomes unbuildable for lower and middle income buyers, or exactly the people townhomes are traditionally targeted towards. This meant that townhomes were essentially disallowed in Houston until 1998, when the rules changed.

In 1998, minimum lot sizes were partially relaxed. The city was divided into “urban” and “suburban” areas. Interstate Highway 610, a loop highway about 5 miles from downtown Houston, divides the two. The old minimum lot size requirements remained in the suburban portion, while the urban places saw their single family detached requirement fall to 3,500 square feet and townhomes shrunk to 1,400 square feet, although they were required to provide at least 600sq.ft. of open space (Lewyn, 2005). While still above the requirements from other cities as mentioned earlier, this gave Houston developers the ability to build townhomes by right nearly throughout the city. With these new regulations, “urban” Houston went from being one of the most difficult places in the country to build townhomes to one of the easiest. Neighborhoods near the city center could now add significant amounts of fairly dense infill housing as the market permitted.

The 1998 zoning change gave Houston the opportunity to densify in much of the city as the market allowed, concentrating in areas of high demand with relatively little constraint. Changes did not occur overnight though. From 1998 to 2004, Houston proper only saw 4,588 owner occupied units constructed (1.4% of total city owner occupied units), so the regulation’s effects were not immediately apparent in the city’s housing market (Lewyn, 2005). The city’s population grew 146,632 from 2000 to 2010 and 167,885 from 2010 to 2017 (A. F. U. C. Bureau, 2018), so it is very likely that an analysis of building after 2004 will show a significant amount of new construction.

Contemporary Houston's minimum lot size regulations have one countervailing force to the smaller sizes. If people petition the city for minimum lot size exceptions for their block or set of blocks, there are processes by which a majority of residents can have the city raise the limit near them (Houston, 2019). Special Minimum Lot Sizes (SMLS) is set at the current lot size of at least 70% of parcels in a given application area (60% for historic districts). If the neighbors show sufficient public support, the city will reset the minimum lot size to the square footage implied by the above figure throughout the application area (the exact figure changes area by area) (Houston, 2019). This is done in the name of neighborhood character and can keep minimum lot size and setback requirements too high for townhome development. The city maintains a current map of such areas that shows significant swaths near and north of Rice University and northwest of Downtown have taken advantage, likely stifling townhome development in those places. Houston's land use has been substantially liberalized, but the change is not universal.

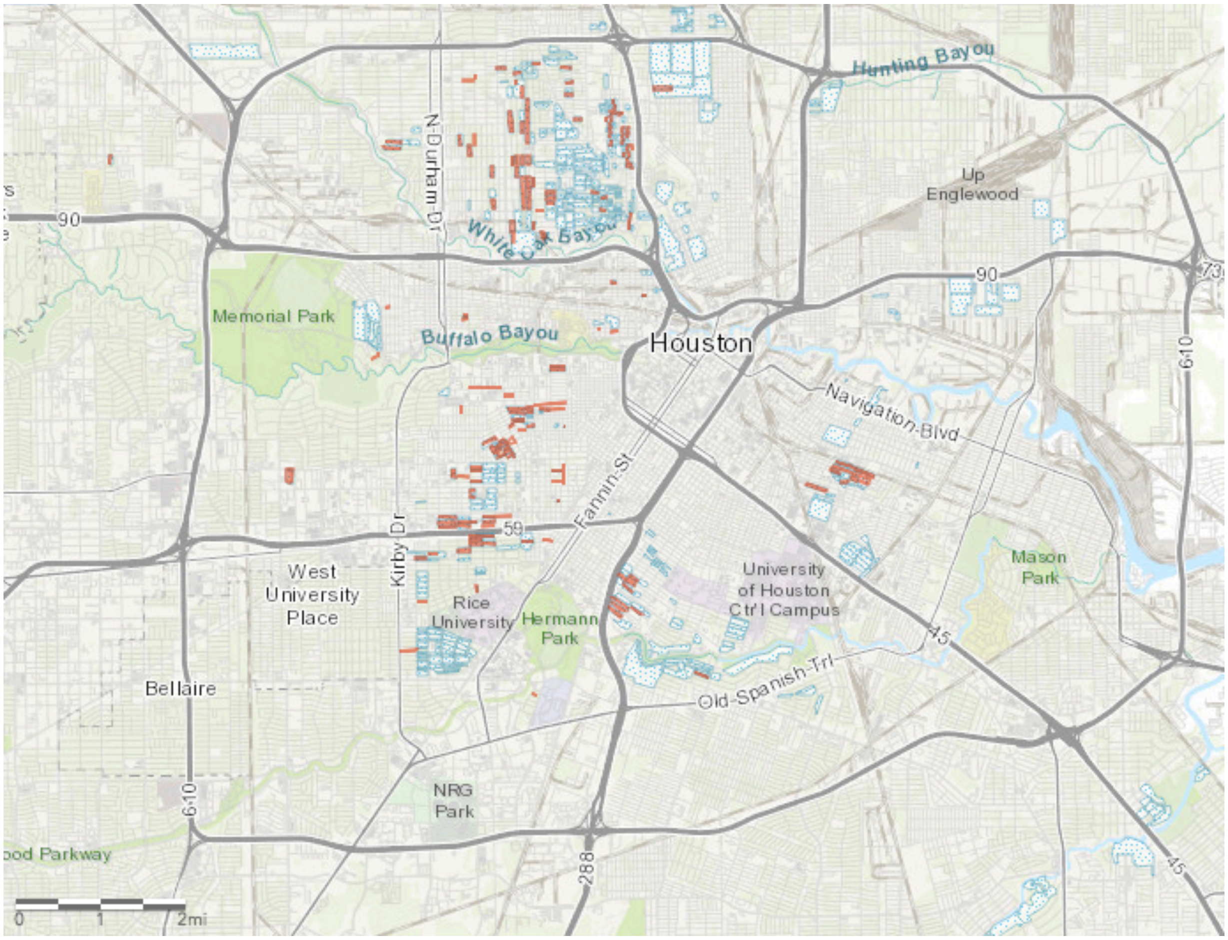

*Figure 1 special minimum lot size (larger lot) areas shown in blue and red*

## Houston History

Houston was founded in 1837 during the Republic of Texas and grew into a railroad hub for Texas by 1890. In 1900 the neighboring port city of Galveston was nearly completely destroyed by a hurricane, and Houston grew as its bayous were dredged to create a protected port (Britannica, 2019). Most of the city's growth came after World War II though. Houston's population grew from 596,163 in 1950 to 2,267,336 in 2017, largely owing to its status as a modern-day capital of the oil industry and significant clusters in petrochemicals manufacturing, refining, rail logistics and seaport (Britannica, 2019). Today, it is the 4th largest city the US and the 5th largest metropolitan area, with a 2018 population of 6,997,384 (U. S. C. Bureau, 2019).

Contemporary Houston is generally known for rapid economic growth, the oil industry, and a sprawling and lightly regulated development pattern.

Houston's recent history has seen periods of strong growth interrupted by recessions. The early 2000s tech bubble recession impacted the city relatively lightly, and Houston experienced strong growth through the mid 2000s until the Great Recession began in 2008. That recession also impacted Houston less harshly than in much of the rest of the country, but there was still a significant slowdown (Thompson, 2010). Growth recovered rapidly in the early 2010s as the price of oil rose to over $100/barrel, but the city's oil industry was significantly impacted by the 2015 oil bust, as West Texas Intermediate (WTI) prices fell from $111.80 in June 2014 to $39.60 in December 2015. Despite oil and related industries shedding 74,200 jobs from 2014 to 2016, growth in Houston's other industries meant that the metro's net job loss was only 3,400 over that period (Gilmer, 2018),(DePillis, 2017). Houston was growing again when Hurricane Harvey struck in 2017. The hurricane had a short but severe impact on the city, with thousands losing their homes and possessions. Rebuilding is mostly complete as of 2019.

## Recent Housing Market History

Metro Houston's housing market has been remarkably stable in recent history. Nominal home prices have risen at a steady rate from 1990 to 2018, with median and average housing prices only falling two and three times respectively over that span (Real Estate Center, 2019). Since 2000, only the onset of the Great Recession has caused annual prices to fall. Even then, median sales prices fell a mere $70 from 2007 to 2008, while average prices fell $5,522 from 2008 to 2009. Aside from that, housing prices have grown every year, including through the early 2000s dotcom bust and the oil bust of 2015-16 (Real Estate Center, 2019). Houston's housing price growth was nearly always steady but also generally slow. Average price growth from 1990 to 2018 was 4.49% nominally and only 1.77% accounting for inflation. Houston housing appreciation topped inflation in roughly two thirds of years over that span and was only rarely far above or below it (Statista, 2019).

Metro Houston's housing sales volume has been slightly less stable than prices. On the whole, available units has moved similarly to prices, but there was a disconnect between the two around the start of the Great Recession. Despite the relative stability of prices over the period, housing sales volume fell from a 2006 peak of 78,326 to a 2010 nadir of 54,922 (Real Estate Center, 2019). Sales also dipped slightly from 2014 to 2015 even as the average sale price rose 3.52%. Overall, Houston has maintained a slow and steady rate of price appreciation despite large population growth.

## Expectations of Townhomes in Houston

Houston has prolifically added supply to meet population growth throughout its history, maintaining a largely balanced for sale housing market. This balanced market should mean that buyers should not feel pressured to purchase townhomes, and people should choose them according to their tastes rather than from pressure from a lack of options. As townhomes proliferate, they should emerge as cheaper alternatives relative to single family detached homes due to their taking up less land, which makes them cheaper to develop and potentially less desirable to buyers.

# Literature Review

## Land Use

Geoffrey Meen and Christian Nygaard studied the impacts of existing land use on price elasticities in two regions in Southeast England, the Thames Valley and Thames Gateway. The Thames Valley is a wealthy, low density area with stringent land controls that is upriver from London (to the West). Conversely, the Thames Gateway was historically worker housing and is now a relatively dense, multi-ethnic area that still contains significant poverty (Meen & Nygaard, 2011). The English government adopted a policy supporting largely brownfield infill development across the country, and the authors wanted to understand how this will affect these very distinct areas. They modeled housing supply, demand, and price and then applied them to construction and land use data from 2004 and 2007 to project expected housing supply elasticities in the two regions. Predicted supply elasticities were higher in the Thames Gateway, largely owing to two factors. The Gateway had more brownfield sites, and the Thames Valley region required more green space in new builds, lowering total new supply additions. Also new housing reduced surrounding properties' prices by reducing their utility gained from lower population densities but that this effect was mitigated by constructing in previously uninhabited brownfields (Meen & Nygaard, 2011).

Bernard Fingleton researched shifts in affordability in southeastern England near London in response to the government's planned housing additions. He performed a cross-sectional analysis to make reasonable theoretical estimates of housing expansion's impacts(Fingleton, 2008). He first found major factors that influence the supply and demand equations for housing, which were then used to find expected housing price reductions stemming from the government's stated housing construction goals in localities across the region due to market slackening. Probable job gains over the period were then generated by extrapolating long term employment and wage trends in the region. Fingleton then refined these to account for job clustering around areas with large scale housing additions and returns to density in a monopolistic competitive market (rising wages). Finally, found change in affordability by comparing the expected impacts on raw housing prices with wage growth. He used GIS to spatially model the interactions and observed that increasing housing supply actually reduced affordability in the central areas while increasing it in the hinterlands, due increase housing costs which outpaced wage gains in central areas. He cautioned that this could produce more environmentally damaging commuting and ended by restating that he had only done a theoretical exercise and not a forecast(Fingleton, 2008). Fingleton intended the paper to attract responses and ignite a larger housing debate.

## Focus on Elasticities

Peter Rydell of the RAND Corporation produced an overview of rental housing price and supply elasticities in the 1980s United States. He begins by positing that the size of price increases is reliant on the size of the demand shift, responsiveness of supply to price, and responsiveness of demand to price (Rydell, 1982). He defines supply elasticity as the percent supply increase given a one percent rise in price, and demand follows the same logic. Supply elasticity generally is very low in the short term but rises to accommodate all new demand in the long term. So, a demand shock will raise prices quickly, but they will eventually even out in real terms.

The author then broke down housing elasticities by type of work performed, namely repairs, inventory addition, and occupancy. He found that the literature, his own figures included, varied widely but generally agreed repair elasticities are very low, inventory very large, and occupancy is greater than zero (Rydell, 1982). Low repair elasticities mean that repairing older properties will be a relatively small component of overall supply responses to market shifts, while the opposite is true of the more elastic inventory addition option (this relationship would reverse if inventory's elasticity dropped below repair's). Repair and inventory are the long term supply responses to meet demand, but the in short term occupancy bears the brunt to the demand/price shift due to its being more flexible in the short term than the former two. Occupancy elasticities are generally considered to be higher when the market is looser than occupancy rates are near 100 percent, because it is easier for people to find empty units quickly in the former scenario.

Overall responses to a demand shock are as follows. Occupancy falls, and prices rise, with the level of the rise increasing as vacancy falls towards zero. Some properties are repaired and a great deal more new units are produced (Rydell, 1982). These have little impact initially due to the time it takes to plan and execute projects but eventually deliveries ramp up to the point where supply and demand rebalance, occupancy falls, and prices reach a new equilibrium.

## Supply and Bubbles

It is well known that long term housing supply and prices are related, but supply elasticities may also affect housing bubbles as they occur. Edward Glaeser and Joseph Gyourko researched supply and housing prices dynamics in market bubbles(E. Glaeser, Saiz, & Gyourko, 2008). They hypothesized that markets that could increase supply quickly would experience milder and shorter bubbles than those in inelastic markets. Furthermore, elastic markets' bubbles would be smaller in magnitude both as the event unfolded and when the bubble burst. They cited historic US housing market data that seemed to reflect those expectations. To test their hypothesis, they modeled supply and demand in equilibrium and bubble conditions. They then paired this with historical construction permitting and price data from 1982-2007, and they used geographic unfavourability as a proxy for supply constraint (they found that natural supply constraints were tightly negatively correlated with an index that measured regulatory constraints). Glaeser and Gyourko concluded that places with higher elasticities did indeed see shorter build up periods and a smaller magnitude when they occurred but failed to show evidence that corrections were milder in more elastic markets (E. Glaeser et al., 2008). Finally, they pointed out that elasticities had an ambiguous effect on overall welfare. Supply increases overran long run demand during booms in highly elastic areas, and this raised the risk of welfare loss after the crash in those places. Neither their model nor historical data clearly pointed to welfare gains or losses in elastic vs. inelastic regions.

Chyi Lin Lee studied the determinants of housing price volatility using national data on the Australian housing market. He looked at data from eight Australian capital cities to determine price volatility from 1987 to 2007. He used MSA level data for quarterly housing prices from the

Australian bureau of Statistics. He also used CPI, income, population, and unemployment rate from the same agency and collected the national mortgage lending rate from the Reserve Bank of Australia (Lin Lee, 2009).

In his methodology Lee first used the Engle LM test to check for volatility clustering and then used an exponential-generalized autoregressive conditional heteroskedasticity (EGARCH) model to eliminate heteroskedasticity and determine volatility in the metros. CPI, income, population, and unemployment rate were all used as dependent variables as well. Lee found that Sydney, Perth, Brisbane, Melbourne, and Hobart showed volatility clustering in the LM test, but the other three cities did not (Lin Lee, 2009).

Lee found that price volatility increased with national inflation and surprisingly was not significantly correlated with short run interest rate volatility, but the other factors were significant to some cities but not others. Unemployment was significantly negatively correlated with volatility in Brisbane and Perth, but not other cities. Income volatility translated into home price volatility in Hobart but not the others (Lin Lee, 2009). Lee concluded that factors influencing housing price volatility varied depending on the metro study and that national housing policy should take locally varying conditions into account.

Paloma Taltavull de la Paz studied supply elasticities in response to price in Spanish land markets from 1990 to 2012. Spain had large scale supply additions in its 2000s economic boom and then crashed in the 2007-2008 global financial crisis, in a pattern similar to the American housing market at that time (Paloma Taltavull de La, 2014). He studied supply elasticities using data for all Spanish regions and the entire country, using datasets from the Spanish Ministerio de Fomento.

He gathered monthly data for the following categories: house building permits, real housing prices, nominal interest rates, CPI, cost of construction materials, and cost of construction labor. He then created an EGL (estimated generated least squares) model based on Meen, Malpezzi, and Glaeser among others to determine the expected impacts of the above variables. He found that housing production was significantly affected both by the positive exogenous shock in 2000 and negative one in the 2007 financial crisis (Paloma Taltavull de La, 2014). Housing price and construction costs were the main significant correlations with supply elasticity, with developers largely halting construction in the crash rather than building at reduced prices.

Much of the literature on housing prices focuses on market efficiency and equilibrium supply, demand, and price, but somewhat less is written on bubbles as they pertain to the market. Angela Black, Patricia Fraser, and Martin Hoesly study housing bubbles through a lens of financial bubble research. They begin by identifying momentum, explosive, and intrinsic as the three types of bubble. Momentum bubbles are formed by irrational expectations that prices will continue to rise simply because they have done so previously. Explosive and intrinsic bubbles are rational and driven by factors exogenous to fundamental asset value (which continue until the exogenous force has been removed) and exogenous fundamentals that are stronger than the given assets (which eventually fall back to asset fundamental levels) (Black, Fraser, & Hoesli, 2006). They then seek to find and define bubbles in the UK housing market. To do this, they employ a unique method of fundamental housing values based on present value of real disposable income as opposed to finding a supply and demand equilibrium. That is to say, they value housing as if it were a financial asset, with the real incomes taking the place of dividends. They use this to highlight the fundamental value growth of housing and compare this to historical gains to see if there is in fact a bubble. They then analyze any extant bubble to check for momentum (irrational) behavior. They then theoretically explain their model for housing fundamental value derived from expected future disposable income and interest rates.

They used quarterly U.K. housing data from 1974 to 2004, with prices coming from Nationwide. They obtain real disposable income and the retail price index (RPI) from the U.K.'s Office of National Statistics and then deflated the housing data by the overall RPI figures to show real housing prices. Plotting the real residential housing prices along with the real disposable income growth shows the cyclical nature of the market apparently (Black et al., 2006). They regressed the two factors against each other and found evidence of cointegration between the two variables, and so they treat them together as stationary. When one variable breaks from the other, then there is evidence of a bubble.

Black, Fraser, and Hoesly then create a vector autoregressive model (VAR) to look for evidence of a bubble and find that real house prices have in fact significantly passed fundamental housing values. They then plot actual real housing prices with fundamental housing values, and it becomes clear that prices diverged from values starting around 2001 (Black et al., 2006).

Upon observing the gap in real prices and fundamental value, they searched for evidence of an irrational momentum bubble, but found that prices generally rose and fell with real disposable income and never deviated too far beyond people's ability to pay for housing. There was some evidence of momentum but only to a small degree. They thus concluded that there was a housing bubble in the U.K. as of 2004, but that it was intrinsic, or driven by fundamental growth from elsewhere (overall economic growth most likely) rather than housing itself (Black et al., 2006). Their work represents a fresh take on house price valuations and stands out in the literature for its application of financial techniques in the context of a housing market.

## Regulation, Supply Additions, and Price

Christopher Mayer and C. Tsuriel Somerville studied how different types of regulation effected prices and supply additions. They considered two categories of land regulation: explicit financial exactions, such as impact fees, and regulations that increase the time to approval of a project (Mayer & Somerville, 2000).

They hypothesized that impact fees raise the rents needed to make projects pencil out, thus dampening construction. Fewer people can afford more expensive rent than the alternative, so developers build to a smaller (luxury) market. The relationship of regulatory delays and construction levels is more complicated, because zoning and permitting area separate choke points that must be considered. In a slow regulatory environment, developers tend to acquire more lots than they intend to develop at any one time to rezone them all before they are needed. Developers can respond quickly to demand if they have an adequate amount of these properly zoned and prepared buffer lots. However, supply additions should still be lower in the long term due to the financial expenses stemming from long approval times.

Mayer and Somerville then regressed data across all US metropolitan regions, measuring quarterly growth rate in real house prices (percent), mean quarterly new housing (permits issued), months to approve subdivision, number of growth management techniques (0, 1, or 2), and use of development fees (binary). The authors found that both regulatory constraints were significantly correlated with lower housing construction. The authors concluded that housing starts can be up to 45 percent lower in highly regulated cities (Mayer & Somerville, 2000). They also found 20 percent lower price elasticities in heavily regulated cities than their lightly regulated counterparts. Impact fees were not found to be large barriers to construction, but time lengthening fees had very strong negative effects on construction across all regression methods.

Regulatory barriers are a major factor in housing price and production that are largely controllable at the local level. Ed Glaeser and Bryce Ward studied regulatory causes and impacts on the Boston area in part to explain large price gains there. They work with a dataset covering 187 cities and towns in the Boston region (nearly all except for Boston proper and Cape Cod) from 1980 to 2002. They begin my showing that land supply constraints do not explain the level of price gains through a bivariate regression (R squared .55) that shows that density in 1980 is actually positively correlated with permits issued in the study period (E. L. Glaeser & Ward, 2009). The places with the most available land generally built the least in that period. They also point out the existence of very expensive, low density towns with very little new construction, the region gained only modest density in the study period, and the average lot size of new homes actually rose over time.

Glaeser and Ward then study regulation in the Boston region. They obtained regulatory data from the Pioneer Institute's Housing Regulation Database for Massachusetts Municipalities in Greater Boston, minimum lot size regulations from the MassGIS system, and permitting and demographic data from the U.S. Census Bureau. They found that average lot sizes ranged from 10,000 to 70,000 square feet, with (unsurprisingly) people disproportionately concentrated in the smaller lots and land concentrated in the less dense places. They also found that cities had adopted stricter wetlands setback regulations by expanding the definition of wetland beyond state requirements (E. L. Glaeser & Ward, 2009). Communities had also adopted a patchwork of rules around septic systems with widely varying and idiosyncratic requirements. Subdivision requirements were also all over the map between cities. What all these rules had in common though is that there were more of them, growing consistently from 1975 to 2004.

The authors then attempted to find out why the regulatory landscape appeared as it did. They found that population density in 1940 alone explained 68 percent of current minimum lot sizes (higher 1940 density correlating to lower minimum lot sizes). It appears that cities were regulatorily capping themselves based on whatever their historic densities had ben. Indeed, percent forest cover in 1885 was found to explain 52 percent of current minimum lot size (E. L. Glaeser & Ward, 2009). Other significant factors with much smaller impacts were percent manufacturing workers in 1940, which was negatively correlated with current minimum lot size and percent white in 1940, which was the opposite.

Wetlands requirements were primarily associated with the amount of area a given town used for aquatic recreation (positive). Those types of places were also more likely to regulate septic requirements more heavily, while more densely populated places were negatively associated with the requirements (they largely used sewers instead). Glaeser and Ward found that most other city specific characteristics were not significantly correlated with regulation of any kind, which may have been related to the widely variation in regulations across similar towns.

To determine the effects of the regulations, they ran a series of regression models with varying combinations of independent variables. They generally found that all regulations were significantly associated with lower construction permit volumes but that minimum lot size had the largest coefficients. To find price effects, they ran several regressions on minimum lot size, demographic characteristics and price. Their first model found that minimum lot size was significantly correlated with higher price values, but when they created another model that accounted for town demographics, minimum lot size coefficient changed direction and lost significance. This shows that minimum lot size in and of itself was not enough to raise land values relative to other locations with similar demographics (E. L. Glaeser & Ward, 2009). They then ran a third model that also included their regulation index, and the minimum lot size was insignificant while the regulation index was significantly correlated with higher prices. This supports the idea that minimum lot sizes were as effective at limiting development as other regulations such as multi-unit development restrictions that could add more affordable units. They then ran further regressions to determine that towns were likely not maximizing overall land value by restricting density.

Glaeser and Ward conclude that the decrease in building permits through the study period is in large part responsible for the Boston region's current high housing prices. Minimum lot size is associated with higher prices when viewed in isolation, but that effect disappears when demographic factors are considered, and increasing density actually has only minor effects on home prices (E. L. Glaeser & Ward, 2009). Glaeser and Ward end the piece by questioning why towns the Boston area would deny themselves the large monetary gains that could come with increased density.

Ned Levine examined the relationship between land use regulations, housing prices, and population distribution in California from 1979 to 1990. Levine uses two surveys on Californian municipal growth regulations taken in 1989 and 1992, covering 443 and 386 of the state's 451 cities respectively. They created an index ranging from 0 to 18 for the number of general growth limiting regulatory measures each city use, and found a 60 percent rise in regulations from 1988 to 1992 despite a recession at the time (Levine, 1999). To explain the boom the authors suggested that the main causes were: stresses related to California's 1980s population boom, accelerated suburbanization, rental unit growth, suburban employment growth, declining federal infrastructure funding, legislative limits on local funding for infrastructure upgrades, and exclusionary tendencies against low income and minority groups. Prices were rising, and Levine looked to see if low income displacement was occurring.

He ran a series of OLS regression models using 1990 housing units as the dependent variable and varying combinations of 1980 units, 1980 density, number of growth control measures enacted with a 0, 1, 2, or 3-year lag. 1980 housing units was the most significant explanatory factor for 1990 units, and the only other significant variable was that the 1 year lagged growth regulations were negatively correlated with 1990 number of units (Levine, 1999). He then categorized the regulatory measures into “strong” and “weak” measures and a third variable for strong measures enacted at the county rather than city level. After running the regressions again, using the new variables lagged by 1 year, he found that the strong measures at the city and county level were significantly, negatively related to housing units in 1990. He ran another regression including rent control and found that this was also significantly negatively correlated to end period housing units. Levine then correlated change of rental and ownership characteristics against 1980 value, 1980 density, and number of 1980 growth control measures.

Key significant relationships included that higher numbers of regulations enacted related to fewer rented units and families, higher median rent level, elevated median ownership value, and median household income (Levine, 1999). He then ran another regression replacing the rental and ownership values with ethnicities and saw that the regulations were significantly negatively associated with total population, non-white, Black, and Hispanic populations. Native Americans were positively correlated with the number of rules, while the White population and senior values were insignificant. Levine concluded that the regulations were stifling development and encouraging minorities to move further away from central areas in search of lower prices.

John Quigley and Steven Raphael studied the costs of regulations on California’s housing market. They assessed whether housing is more expensive in more heavily regulated cities, determined whether or not the price of housing at the end of a decade depends on the city’s regulations at the start of it, and they lastly tried to find the price elasticities in more and less regulated markets. Quigley and Raphael created an index of regulation levels in Californian cities and then measured that against housing price in 1990 and 2000. The former data is derived from a 1992 survey of California local governments in a similar manner to Levine (Quigley & Raphael, 2005). The latter data is derived from the U.S. Census Public Use Microdata Samples (PUMS). This data also includes structure features such as number of rooms and bedrooms, unit age, number of units in the structure, whether the unit is a condominium, the presence of complete kitchen and plumbing, and rental vs. ownership status.

They performed a hedonic analysis on the price effects on owner and rental housing from regulatory burdens and found that the number of controls was significantly positively correlated with price for both types with and without accounting for county fixed effects across 1990, 2000, and the change between the periods. They ran another series of regressions for building permits of all units, single family, and multifamily units, and found that total housing change was significantly negatively correlated with regulatory levels when taking the price index into account and that single family homes were significantly negatively correlated with regulation. They found no effect no multifamily growth though (Quigley & Raphael, 2005). The authors then used imputed variables (IV) regression to estimate the impact of regulation on price elasticity. They discovered that the overall housing stock elasticities had a significant positive correlation with "unregulated" cities and a significant negative one with the "regulated" ones. The single family category was less conclusive, with only a barely significant negative correlation between price elasticities and regulated cities. Multifamily had the strongest results with unregulated cities having far more elastic prices than unregulated ones.

Quigley expanded upon his California research themes in a work submitted to a land policy conference on regulation and property values nationally. Quigley begins by stating that U.S. zoning regulatory policy differs from most other U.S. regulatory policies, because it relies more on norms and vague legal concepts than scientifically deduced best practices (Quigley, 2007). He then lays out a basic economic argument against restrictive rezoning with supply and demand curves and welfare loss resulting from reduced supply. He points out that homeowners have much to gain from keeping housing supply restricted, because they receive the benefit from inflated prices. He goes on to say that homeowners are not simply benefiting from negative externalities but that they are actually acting as monopolistic actors, trying to keep prices up consciously.

He then uses theoretical equations to explain how restricting land use drives up prices and pushes development further from the center of the city. Quigley presents evidence from recent (as of 2006) research that shows housing prices have diverged from building costs since the mid-1980s as restrictions grew more stringent. He plotted average housing prices in metro areas across the country with two of Malpezzi's regulation indices and found that they both indicated prices increasing with regulatory burden (Quigley, 2007). Finally, he discussed his above 2004 work with Raphael to further reinforce his point that regulation drives up housing prices unnecessarily.

C.J. Gabbe studied the effect of regulations on housing prices in two Los Angeles Metro stops, Koreatown and Vermont/Western. He chose the two Metro stops because in 2001 (16 years before the study) Vermont/Western was made the center of one of Los Angeles' first transit oriented development areas that receive upzoning and relaxed regulatory requirements while Koreatown is a large rail adjacent neighborhood that has traditional zoning and requirements (Gabbe, 2018).

Vermont/Western operates under a Transit Oriented Development Specific Plan: Station Area Neighborhood Plan (SNAP) set of ordinances. The plan regulations raised density limits in some areas, reduced parking minimums and imposes maximum on new builds, allows adaptively reused buildings to skirt parking requirements. It trades these things for impact fees for parks, transitional height limits, design guidelines, and a voluntary density bonus program for affordable housing (form of inclusionary zoning, IZ) (Gabbe, 2018).

To determine any effect these lighter regulations had on developer behavior and prices, Gabbe conducts an analysis of buildings in Vermont/Western and Koreatown and interviews local planners and developers. Gabbe used a City of Los Angeles dataset to quantify units approved between 2006 and 2016 and then used Google Street View to verify whether buildings were complete by early 2017 (Gabbe, 2018). 16 projects met both criteria.

Koreatown is a dense neighborhood near downtown with three transit stops but no TOD specific plan. In this area, he found 39 qualifying projects and then selected 16 at random for comparison with the Vermont/Western projects.

The author found that developers routinely took advantage of IZ related density bonuses, such that the average development in the neighborhood was over normally permitted height and floor area ration (FAR) requirements. He found that in comparison to Koreatown, developments were generally smaller, shorter, and had slightly less off-street parking per unit (Gabbe, 2018). This was largely due to Vermont/Western developments being capped by the transitional height requirement while Koreatown had FAR requirements but no height limit (and that FAR was higher than Vermont/Western's).

Interviews with planners and developers revealed that Vermont/Western's SNAP requirements were difficult to work with due in part to their complexity and uniqueness in the city's regulatory landscape. Other barriers included difficulty fitting projects under the transitional height limit, and parcel assembly was more difficult in the SNAP district. Parking requirements and density limits were seen as major obstacles in both places. Developers were also generally wary of Los Angeles' onerous development process that allows little "by right" construction and typically ends up in a protracted negotiation with city hall (Gabbe, 2018). This was problem was not confined to either area.

Gabbe concludes that planners and politicians need to consider not only the broad policy of the regulations they write but also the details of their implementation. Policies meant to spur development, such as Vermont/Western's SNAP regulations may not actually induce development (let alone equitable development) as hoped if the implementation leaves a complicated regulatory landscape that it difficult to navigate (Gabbe, 2018). Planners should listen more to developers to understand their needs better when crafting specific regulations to implement broader policy.

## Land Costs

Arthur Grimes and Andrew Aitken wanted to better understand the relationship of land costs, housing supply, and price. So, they analyzed a longitudinal dataset covering all 73 administrative regions in New Zealand for at least 53 quarters. This data captures land value, construction permits, and home prices among other things, erasing a limitation from earlier studies (Grimes & Aitken, 2010). Lacking quality land price data had forced other researchers to assume a certain land cost as a percentage of overall costs. This meant that while others could model price and supply, land prices were effectively static in their models.

They hypothesized that higher land costs would depress overall construction levels and supply elasticities and constructed a model that includes an assumed sticky short term supply, expected house prices at given levels of demand, and housing costs. Their findings largely confirm Glaeser and Gyourko's finding that more expensive regions have lower supply elasticities. Their key finding though was that higher land costs themselves dissuaded construction and lowered supply elasticities (Grimes & Aitken, 2010). They concluded that knowledge of land and development costs could lead to more accurate supply predictions in other places like the U.S. than had been produced up to that point.

## Construction Costs

Construction costs are widely recognized in the literature as important to the overall price and price and supply elasticities of housing stock. Joseph Gyourko and Albert Saiz examined those costs in detail. They noted prior to executing the main body of the study that national prices of construction goods materials were essentially unchanged in real terms since 1980, but there was significant regional variation in costs (Gyourko & Saiz, 2006). They examined construction costs at the metropolitan level and found a 20 percent cost difference within the interquartile range across all the cities, and their study was to find out why.

They used data from RS Means Company for 140 metros and nationally covering materials, labor, and equipment costs for economy, average, custom, and luxury quality levels. The data are also divided by unit size, number of other stories, and other traits such as whether or not there was a basement. This construction data is paired with housing construction permit data from the U.S. Census Bureau to look for supply impacts. Gyourko and Saiz also used population density data (derived from political unit geographic sizes from the 2002 *County and City Data Book* and populations from the Bureau of Economic Analysis' (BEA) Regional Information System (REIS) and a measure of topography favorability (from the U.S. Department of Agriculture's Economic Research Survey (ERS)), because both of those factors have been associated with higher construction costs (Gyourko & Saiz, 2006). Local wages (from the U.S. Bureau of Labor Statistics) and unionization rates (from the *Current Population Survey*). They created a "Building Regulatory Chatter" metric derived from internet search hits and used per capita expenditures on "protective inspection and regulation" (from the 2002 *Census of Governments*) as proxies for the level of local regulatory constraints. Finally, the found the size and number of construction businesses in each metro through the U.S. Census Bureau's *County Business Patterns* publication.

They analyzed all of the above vectors through ordinary least squares (OLS) regression and an Imputed Variable (IV) regression. The found that supply elasticities for material goods were high, so places with high building activity only saw modestly higher construction materials costs than the low demand areas. Conversely, Union Strength was a significant factor in increasing construction costs, with 11 percent higher costs associated with moving from the third to first quartile of union penetration (10 and 32 percent respectively). However, observed that union penetration was having little impact on durable goods (which should be related to construction costs) prices and concluded that areas with higher unionization were more expensive, but likely for other reasons than the unions themselves (Gyourko & Saiz, 2006). Wages were significantly correlated with construction costs, with the latter rising 7.6 percent across the interquartile range of wages. They found little meaningful impact of regulation on costs, but they stated that this was likely due to the inadequacy of their measures of the vector. Their dummy variable for rugged terrain was significantly correlated with costs. Density was also positively and significantly correlated with costs, but it made very little difference across most cities. New York and San Francisco had noticeable bumps in costs related to this factor, but those rises are mostly confined to the extreme end of the data. Their model explained 80 percent of construction cost variation. Of all the variables, they concluded that unionization and wage levels together along with rugged terrain had the greatest impact on construction costs.

Stuart Rosenthal investigated the efficiency of the housing market as it pertains to construction costs and the residential market. He worked from a theoretical presumption that new construction of a new building alone (not the land it sits on) has an equilibrium equal to current construction costs, while older buildings have separate equilibrium prices based on "past and current values of the relative cost of vacant land to capital" (Rosenthal, 1999). Risk-adjusted rates of return should be equal in the long term across assets and asset classes.

Rosenthal used data from the British Columbia Assessment Authority (BCAA) for all single-family detached home sales in Vancouver, B.C. 1979-1989. The data also includes characteristics such as neighborhood name (10 categories), structural, and lot characteristics. He then created a hedonic analysis model price is the sum the neighborhood, lot size, corner lot dummy, new, medium and old age categories, and a composite vector for structural characteristics such as square footage and number of bedrooms. Next, he added additional data from the Canada Mortgage and Housing Corporation (CMHC) for construction costs across time. He then ran a number of tests and data transformations to find and correct for any unit root or cointegration problems before creating seemingly unrelated regressions (SUR) models for housing starts and single family homes under construction (Rosenthal, 1999).

Rosenthal concludes from the models that both new and old buildings (again, this is structures only, not land) generally follow equilibrium prices and revert to the mean roughly two quarters following a supply shock. He finally concludes that, because the building construction market itself is efficient, any inefficiencies in the housing market must arise from the land market itself.

## Intra-regional Price Variation

While it is well known that more central areas in a region are generally more expensive than outlying ones, the exact relationship of how one effects the other is less well understood. Elias Oikarinen studied the lead-lag relationship between the core of the Helsinki metro and its suburbs, the Helsinki metro area (HMA) to other regions in Finland, and finally the lead-lag relations between central markets and their hinterlands (Oikarinen, 2006). The intra-metropolitan lags are the most pertinent here, and so only that section of the study will be summarized.

Oikarinen begins by noting that real estate markets experience spatial lags in theory, because of thin markets, high transaction costs, dispersed information, and time delays in the spread of information skew even a fully rational market. He then goes on to say that in small countries such as Finland or regions/MSAs of large ones, central areas generally experience economic growth earlier in business cycles than outlying ones (Oikarinen, 2006). Another reason for centrally-led regional price lags may be that the most informed actors in the housing market concentrate in the center of large cities because they house more institutions and large businesses than outlying regions. This puts core areas in a position to react faster to economic trends than the peripheral ones. Another factor may be that migration tends to effect core areas first, with new residents looking further afield after prices rise there, causing the effect to spread outward. It should be noted that this situation is prone to reversal if job gains are concentrated in outlying areas, because migrants are likely to concentrate around employment centers.

To study the metro level price lags, Oikarinen uses quarterly hedonic price indices provided by Statistics Finland from 1987 to 2004. The data is broken into Helsinki's core and peripheral areas. The author uses a series of econometric tests to show that the central and outer areas of the Helsinki metro are related to each other but not actually cointegrated. He found that the price change in the center did not cause price change in the metro area, but that metro area change caused price rises in the center despite price rises being much larger in the center than the whole MHA (Oikarinen, 2006). This seems to be due to overall immigration into the MHA being met by inelastic supply in the center, while the outer parts of the metro can grow more. He also noted that wider MHA had been adding much more jobs than the center over the period, so it did make some sense for the overall area's growth to be fueling price rises in the core. Finally, he stated that the wider MHA was much larger than the center, so adding a small number of people relative to the MHA could cause a price spike in the center, while leaving most of the metro unaffected.

## Methodology

To find whether or not townhomes provided a relatively affordable option against single family houses, one must find a way to split the townhome itself from other types of property as well as other confounding factors such as square footage, lot size, and year built. This suggests that a hedonic analysis is an appropriate technique for our purposes.

Hedonic analysis is the process of using multivariate regression to split the dependent variable (price or value in this case) and multiple independent variables with varying levels of potential influence. The coefficients of the significant independent variables suggest the change of dollar value associated with adding or increasing the amount of a given feature on price. While a hedonic analysis, like any form of regression, does not prove causality, it does point to trends in the data that may be interpreted against theoretical expectations. Hedonic analysis also carries the advantage of separating and making visible factors that would otherwise make housing price data incomparable.

Hedonic analysis requires large datasets with multiple variables relevant to home values, and the best source of such data in the Houston metro area is the Harris County Appraisal District (HCAD). HCAD keeps publicly available data for years 2005 to 2018 for all properties within Harris County. Its datasets include things such as structure type, location, appraisal values, size, features and more, and they constitute the most accurate, up-to-date, and thorough information publicly available for the City of Houston (District, 2019). Unfortunately, the state of Texas has a property sale price confidentiality law that allows buyers and sellers to agree to keep their sale price out of public data (Batheja, 2015). Requesting the redacted sales price data from HCAD left a dataset that was too incomplete to be a quality source for analysis and working with the non-redacted sales data could also have compromised the analysis due to the price disclosing minority possibly not being representative of typical home buyers and sellers. Those data limitations lead to appraisal values being used as the dependent variable for home value. While not being true statements of value in the way that sale prices are, appraisal values are a reasonable proxy and should follow the same trends as sale price.

The data was downloaded from HCAD's website and coded in R software. Data from multiple categories and each year was appended into a master dataset which could then be analyzed. Dummy variables were created for townhomes and single family residences, and date erected, year remodeled, heat area, and lot size were all used as continuous variables. The final equation was:

Total Appraised Value = Townhomes + Date Erected + Year Remodeled + Heat Area + Lot Sie + Constant

The analysis based on the above equation was run for the whole study period and then again for each year to determine trends throughout the period.

## Analysis

The analysis for the whole period was run first. All factors were statistically significant, either at the one percent or five percent level. Townhomes were cheaper over the whole period, but the $667.19 discount associated with them is quite small in the context of an entire home purchase. Date erected was more negative at -$2,877.60, signifying older homes were more valuable. Year remodeled was positively associated with appraisal value though, and home values also rose along with heat area. Lot size was significant but had a negligible impact. The R squared value was .331, so the analysis likely contained factors accounting for about a third of total home value.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value 2005-2017 |
| Townhomes | -667.194** |
| | (296.497) |
| Date Erected | -2,877.602*** |
| | (2.799) |
| Year Remodeled | 31.609*** |
| | (0.092) |
| Heat Area | 230.826*** |
| | (0.058) |
| Lot Size | 0.0001*** |
| | (0.00001) |
| Constant | 5,475,176.000*** |
| | (5,502.353) |
| Observations | 34,676,541 |
| R2 | 0.331 |
| Adjusted R2 | 0.331 |
| Residual Std. Error | 331,443.500 (df = 34676535) |
| F Statistic | 3,438,505.000*** (df = 5; 34676535) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

2005 saw Townhomes were worth $5,062.88 more than single family detached homes, a substantial difference from the overall period and a sign change. The other variables showed similar results to the whole period.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2005 |
| Townhomes | 5,062.882** |
| | (2,531.077) |
| Date Erected | -1,734.070*** |
| | (22.154) |
| Year Remodeled | 22.600*** |
| | (0.748) |
| Heat Area | 158.870*** |
| | (0.497) |
| Lot Size | 1.032*** |
| | (0.013) |
| Constant | 3,279,618.000*** |
| | (43,217.310) |
| Observations | 258,458 |
| R2 | 0.327 |
| Adjusted R2 | 0.327 |
| Residual Std. Error | 210,862.300 (df = 258452) |
| F Statistic | 25,135.180*** (df = 5; 258452) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

In 2006, the positive correlation between townhomes and value strengthened to $17,532.85 and its confidence level rose to the 1% level. The other factors behaved similarly to the whole period.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value 2006 |
| Townhomes | 17,532.850*** |
| | (1,461.133) |
| Date Erected | -1,545.098*** |
| | (12.667) |
| Year Remodeled | 27.085*** |
| | (0.483) |
| Heat Area | 160.007*** |
| | (0.291) |
| Lot Size | 2.327*** |
| | (0.013) |
| Constant | 2,899,727.000*** |
| | (24,810.570) |
| Observations | 690,464 |
| R2 | 0.357 |
| Adjusted R2 | 0.357 |
| Residual Std. Error | 208,682.000 (df = 690458) |
| F Statistic | 76,820.030*** (df = 5; 690458) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhomes remained more expensive than the average house in 2007, although the difference declined slightly. Otherwise, the year was similar to 2006 and the whole study period.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2007 |
| Townhomes | 14,231.890*** |
| | (1,102.737) |
| Date Erected | -1,983.503*** |
| | (9.744) |
| Year Remodeled | 23.581*** |
| | (0.377) |
| Heat Area | 173.957*** |
| | (0.215) |
| Lot Size | 1.019*** |
| | (0.007) |
| Constant | 3,762,376.000*** |
| | (19,108.720) |
| Observations | 1,197,657 |
| $R^2$ | 0.386 |
| Adjusted $R^2$ | 0.386 |
| Residual Std. Error | 211,816.900 (df = 1197651) |
| F Statistic | 150,872.900*** (df = 5; 1197651) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

The trends from 2007 largely remained the same in 2008, although townhome value increased again relative to single family home value.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2008 |
| Townhomes | 18,443.090*** |
| | (998.986) |
| Date Erected | -1,910.808*** |
| | (8.981) |
| Year Remodeled | 31.847*** |
| | (0.352) |
| Heat Area | 190.305*** |
| | (0.195) |
| Lot Size | 1.281*** |
| | (0.007) |
| Constant | 3,590,101.000*** |
| | (17,638.090) |
| Observations | 1,611,440 |
| R2 | 0.407 |
| Adjusted R2 | 0.407 |
| Residual Std. Error | 231,172.500 (df = 1611434) |
| F Statistic | 221,498.200*** (df = 5; 1611434) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhome values further strengthened in 2009, and heat area continued a trend of slow growth, although it was still below the whole period average.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2009 |
| Townhomes | 24,385.430*** |
| | (896.052) |
| Date Erected | -2,217.014*** |
| | (8.687) |
| Year Remodeled | 27.803*** |
| | (0.331) |
| Heat Area | 201.879*** |
| | (0.184) |
| Lot Size | 1.681*** |
| | (0.007) |
| Constant | 4,168,207.000*** |
| | (17,065.550) |
| Observations | 1,980,405 |
| R2 | 0.416 |
| Adjusted R2 | 0.416 |
| Residual Std. Error | 243,835.800 (df = 1980399) |
| F Statistic | 282,193.200*** (df = 5; 1980399) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

In 2010, prices fell somewhat for townhomes but remained above single family prices. Other factors were fairly stable relative to the other years.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2010 |
| Townhomes | 13,347.310*** |
| | (831.580) |
| Date Erected | -2,467.152*** |
| | (7.998) |
| Year Remodeled | 19.737*** |
| | (0.296) |
| Heat Area | 203.254*** |
| | (0.170) |
| Lot Size | -0.00001 |
| | (0.00002) |
| Constant | 4,671,777.000*** |
| | (15,710.680) |
| Observations | 2,299,446 |
| R2 | 0.402 |
| Adjusted R2 | 0.402 |
| Residual Std. Error | 244,211.400 (df = 2299440) |
| F Statistic | 308,518.200*** (df = 5; 2299440) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhomes values fell noticeably in 2011 and had a sign change. This was the first year in the analysis where townhomes were more affordable than single family detached houses. Year remodeled also flipped from positive to negative for the first time, aligning for the first time with the consistently negative date erected factor.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2011 |
| Townhomes | -9,959.940*** |
| | (962.501) |
| Date Erected | -3,410.002*** |
| | (9.241) |
| Year Remodeled | -10.876*** |
| | (0.326) |
| Heat Area | 193.762*** |
| | (0.193) |
| Lot Size | 0.00004* |
| | (0.00002) |
| Constant | 6,590,753.000*** |
| | (18,151.550) |
| Observations | 2,687,497 |
| R2 | 0.280 |
| Adjusted R2 | 0.280 |
| Residual Std. Error | 300,761.500 (df = 2687491) |
| F Statistic | 209,354.100*** (df = 5; 2687491) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

2012 continued and reinforced the trends from 2011, with townhome value relative to single family falling under -$10,000 for the first time.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2012 |
| Townhomes | -12,425.630*** |
| | (926.318) |
| Date Erected | -3,520.181*** |
| | (8.879) |
| Year Remodeled | -13.678*** |
| | (0.300) |
| Heat Area | 199.187*** |
| | (0.184) |
| Lot Size | 0.0001** |
| | (0.00002) |
| Constant | 6,798,495.000*** |
| | (17,446.380) |
| Observations | 3,014,795 |
| R2 | 0.287 |
| Adjusted R2 | 0.287 |
| Residual Std. Error | 306,106.000 (df = 3014789) |
| F Statistic | 242,758.700*** (df = 5; 3014789) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhomes remained the cheaper option in 2013, although the difference was smaller than the year prior.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value 2013 |
| Townhomes | -9,063.609*** |
| | (906.380) |
| Date Erected | -3,334.598*** |
| | (8.628) |
| Year Remodeled | -10.667*** |
| | (0.283) |
| Heat Area | 209.769*** |
| | (0.179) |
| Lot Size | 0.0001** |
| | (0.00003) |
| Constant | 6,415,348.000*** |
| | (16,960.680) |
| Observations | 3,390,254 |
| R2 | 0.298 |
| Adjusted R2 | 0.298 |
| Residual Std. Error | 316,553.500 (df = 3390248) |
| F Statistic | 288,412.600*** (df = 5; 3390248) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

In 2014, relative townhome values remained negative, but the difference moderated substantially from 2012 and 2013. The confidence level also receded slightly to the 5% level.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2014 |
| Townhomes | -1,951.391** |
| | (931.752) |
| Date Erected | -3,780.171*** |
| | (8.821) |
| Year Remodeled | -11.522*** |
| | (0.282) |
| Heat Area | 237.319*** |
| | (0.182) |
| Lot Size | 0.0001*** |
| | (0.00003) |
| Constant | 7,263,577.000*** |
| | (17,346.120) |
| Observations | 3,785,450 |
| R2 | 0.320 |
| Adjusted R2 | 0.320 |
| Residual Std. Error | 342,691.600 (df = 3785444) |
| F Statistic | 356,666.400*** (df = 5; 3785444) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

2015 saw relative townhome values revert to positive against single family homes, while all other factors remained similar from the year before.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2015 |
| Townhomes | 1,890.978** |
| | (938.977) |
| Date Erected | -3,934.284*** |
| | (8.985) |
| Year Remodeled | -11.033*** |
| | (0.285) |
| Heat Area | 263.375*** |
| | (0.184) |
| Lot Size | 0.0001*** |
| | (0.00004) |
| Constant | 7,543,243.000*** |
| | (17,675.800) |
| Observations | 4,202,205 |
| R2 | 0.338 |
| Adjusted R2 | 0.338 |
| Residual Std. Error | 369,131.800 (df = 4202199) |
| F Statistic | 428,964.100*** (df = 5; 4202199) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhomes grew more expensive than single family homes again in 2016, although the coefficient remained below seen in and before 2010. Year remodeled also returned to positive.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2016 |
| Townhomes | 5,638.926*** |
| | (895.132) |
| Date Erected | -2,442.189*** |
| | (8.639) |
| Year Remodeled | 85.360*** |
| | (0.258) |
| Heat Area | 268.774*** |
| | (0.174) |
| Lot Size | 0.003*** |
| | (0.0002) |
| Constant | 4,555,041.000*** |
| | (17,017.960) |
| Observations | 4,581,817 |
| R2 | 0.378 |
| Adjusted R2 | 0.378 |
| Residual Std. Error | 368,390.700 (df = 4581811) |
| F Statistic | 557,945.100*** (df = 5; 4581811) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Townhomes spiked in 2017 to $40,220.56 more expensive than the typical single family detached home, by far the highest gap in the period and also the largest shift between periods.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2017 |
| Townhomes | 40,220.560*** |
| | (852.067) |
| Date Erected | -1,986.413*** |
| | (8.167) |
| Year Remodeled | 51.623*** |
| | (0.244) |
| Heat Area | 275.235*** |
| | (0.164) |
| Lot Size | 4.971*** |
| | (0.006) |
| Constant | 3,603,574.000*** |
| | (16,097.350) |
| Observations | 4,976,653 |
| R2 | 0.435 |
| Adjusted R2 | 0.435 |
| Residual Std. Error | 363,609.200 (df = 4976647) |
| F Statistic | 767,753.600*** (df = 5; 4976647) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

Finally, 2018 saw townhomes fall from 2017 but still end at the second highest value in the study period. Lot Size rose slightly but remained near zero.

| | Appraised Home Price |
|---|---|
| | Total Appraised Value |
| | 2018 |
| Townhomes | 27,348.530*** |
| | (834.591) |
| Date Erected | -2,014.110*** |
| | (7.920) |
| Year Remodeled | 45.586*** |
| | (0.233) |
| Heat Area | 272.934*** |
| | (0.159) |
| Lot Size | 4.270*** |
| | (0.006) |
| Constant | 3,671,794.000*** |
| | (15,616.870) |
| Observations | 5,371,755 |
| R2 | 0.418 |
| Adjusted R2 | 0.418 |
| Residual Std. Error | 368,577.800 (df = 5371749) |
| F Statistic | 771,398.300*** (df = 5; 5371749) |
| Note: | *p<0.1; **p<0.05; ***p<0.01 |

## Results

Townhomes are often considered a more affordable option to single family detached housing, but this condition was tenuous at best in Houston during the study period. Townhomes were slightly more affordable than single family homes over the whole study period, but the individual year analyses showed townhomes swinging broadly in value against single family detached housing. Townhomes' relative value swings far more than anything else in the regression, with the first five years showing consistently higher values, lower values from 2011 to 2014, mildly positive value in 2015-16 and finally a relative value spike in 2017 and 2018. Why does townhomes relative value swing so much? More research is required to know conclusively, but the other variables suggest an explanation.

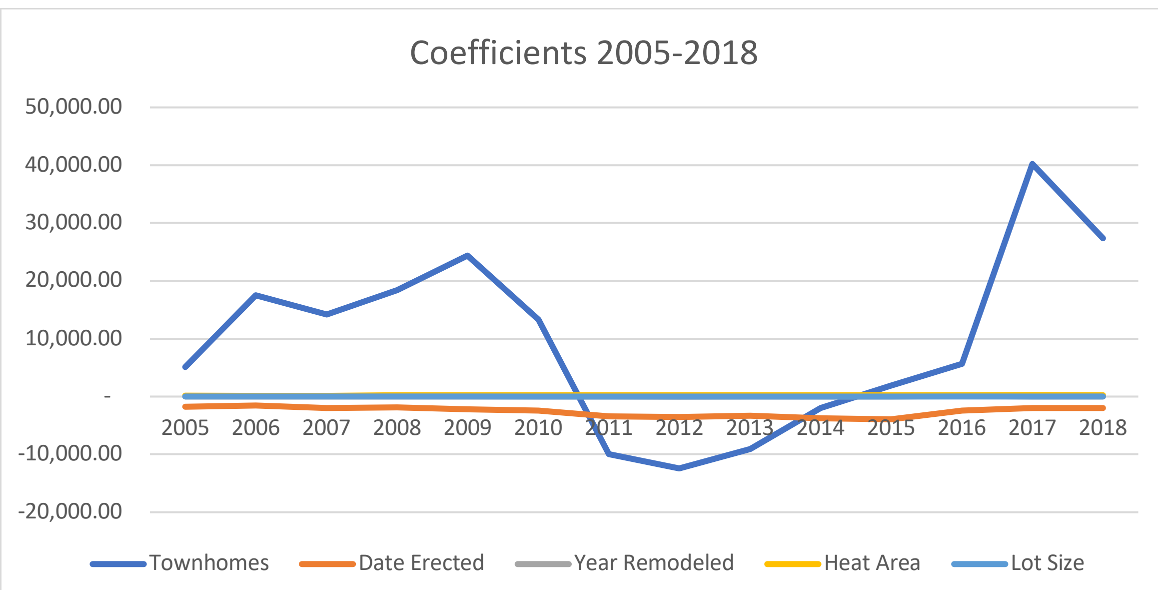


*Figure 2 Source: Harris County Appraisal District*

Townhomes swing with much more apparent magnitude than the other coefficients, but it should be noted that comparing the value movements associated with a dummy variable's presence could be expected to have a much larger impact than a one unit increase in a continuous variable such as heat area. The key takeaway is not the other factors' relative size to townhomes, but their coefficients' changes throughout the study period. Below is the same chart without townhomes.

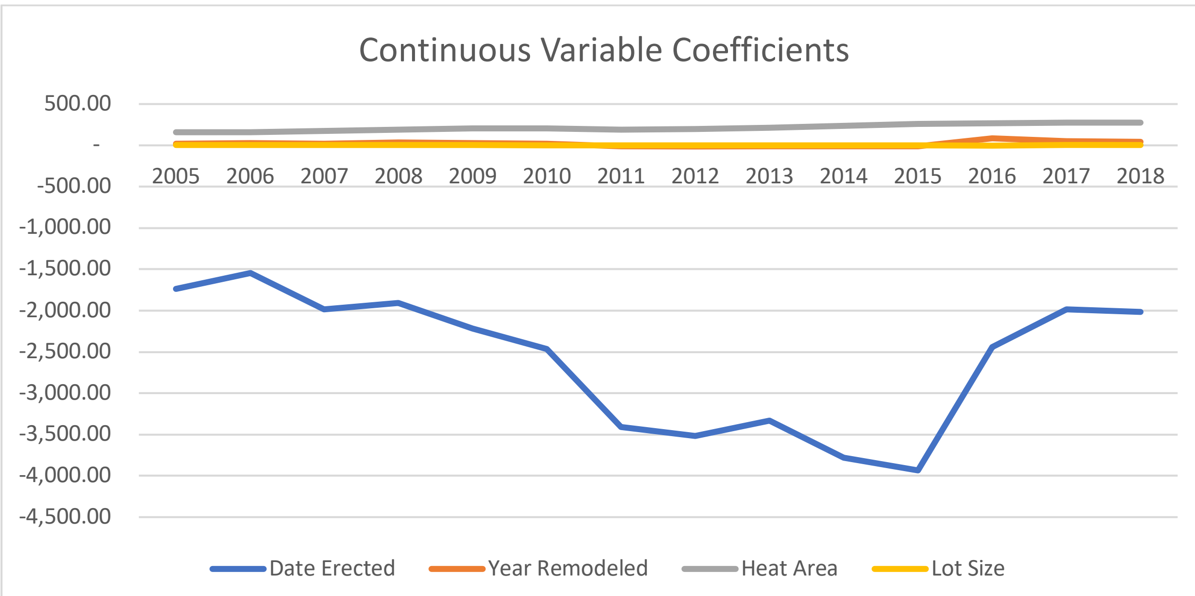


*Figure 3 Source: Harris County Appraisal District*

Here one can see that most of the other variables do not carry the same drastic sign changes that characterize townhomes, but date erected does move in a pattern vaguely similar to townhomes, although the sign is always negative. The variable shows Houstonians having a consistent preference for older homes, which is curious as it does not line up with a general expectation of a preference for newness or the positive indicator associated with year remodeled. This pattern may reflect the way HCAD collected and catalogued the data, or it could be due to the possible presence of older yet luxurious neighborhoods that skew the data away from expected patterns. The magnitude of the date erected variable still renders the other variables difficult to observe. Here are the remaining factors graphed without the townhomes and date erected.

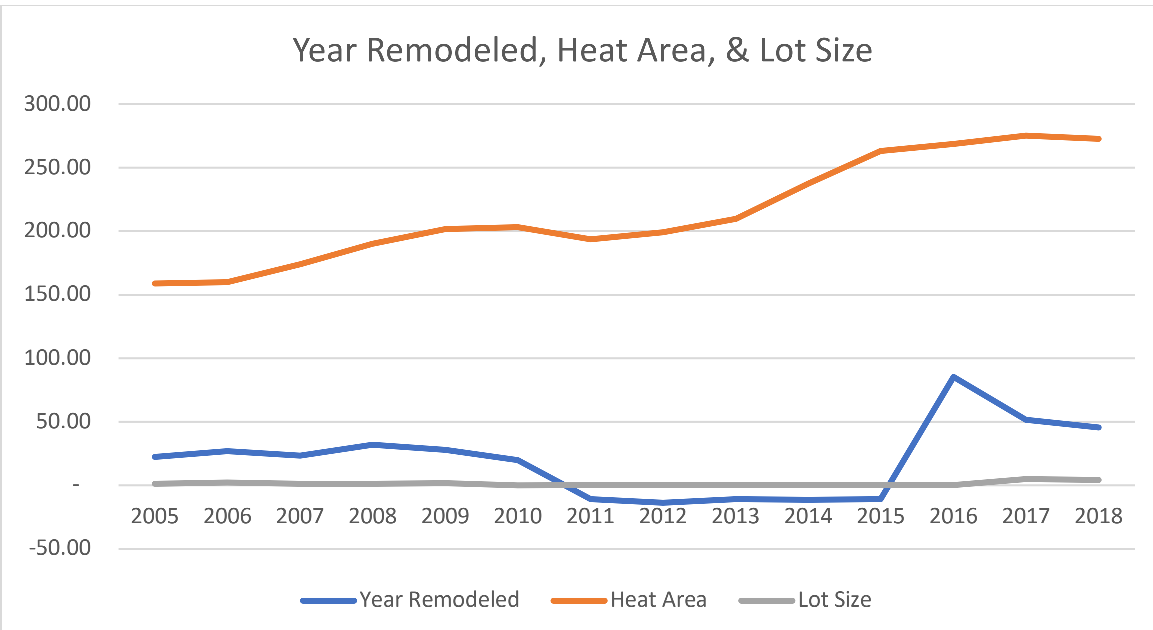


*Figure 4 Source: Harris County Appraisal District*

Once clearly visible, the remaining variables show some interesting patterns that may help to explain townhomes' vacillating values. First, year remodeled is the only variable other than townhomes to see a notable sign change, and it aligns fairly well with townhomes, flipping negative in the same year and reverting to positive one year later. It seems plausible that the market conditions from 2011-15 were different from earlier and later periods, and that townhomes, year remodeled, and perhaps date erected all reacted accordingly.

The central question of why townhomes swung in value so substantially against single family homes may be answered in part by the trends seen in heat area and lot size. Heat area enters the period at $158.87 dollars of associated additional value for each extra square foot of heat area and then consistently rises throughout the study period, ending at $275.24. At the same time, lot size begins with a 1.03 coefficient and remains essentially at zero throughout the study period. This suggests that Houstonians are willing to pay significant sums for more square footage, but they will not be willing to pay more for a house with a large yard than a similar home with a small one.

The above point is critical, because the central value proposition for townhomes against single family detached is that people are willing to pay less for houses with little land than those with more and that builders are able to satisfy the lower demanded price by splitting land costs among more units. The above relationship however means that townhomes with similar heat area and features to single family detached units will fetch roughly the same price, so builders have the flexibility to build townhouses across a wide swath of price points. They can find demand for more luxurious units, or they can offer cheaper units than single family developers can in a down market.

## Conclusion

The results suggest that townhome builders have significant flexibility to chase multiple price segments depending on demand, and the trends in townhome price along with date remodeled and year erected suggest that they did target different segments during the study period. The

Houston economy was performing well during the mid 2000s, and it seems that townhome builders targeted the higher end of the market in that period, consistently charging more than single family homes in the city before falling below them from 2011 to 2014.

Year remodeled being positive or negative suggests whether homebuyers were willing to pay extra for more up-to-date homes as opposed to merely serviceable ones, and indirectly is a proxy for the strength of the luxury market against middle and lower market segments. The variable's coefficient switching to negative from 2011-15 then suggests that Houston market was skewing towards more value conscious buyers over that period. It seems probable that townhome builders reacted to this market by shifting towards smaller, somewhat more affordable units over that period, and then started to build more relatively expensive units again at the end of the period.

During the 2011-15 period, developers would likely have needed to build smaller and denser than earlier years to make relatively cheaper houses, so it could be expected that they might try to raise construction volume to maintain overall profits. The negative townhome coefficient for the overall study period despite the majority of years showing positive coefficients, including the highest absolute value coefficients, does suggest that volume was higher in the 2011-15 period. The overall number was likely skewed down by high volume in those years. The 2017 data shows a large spike in townhomes' relative price, but the Houston housing market and the city generally were hugely disrupted by Hurricane Harvey that year, so that data should be viewed as an outlier and not representative of typical market conditions. The 2018 figure showed moderation relative to 2017, but it is possible that the city's housing market was affected in that year as well.

The expectation that townhomes will be cheaper than single family homes because of lower demand for the housing type and lower building costs from more efficient land use is only partly supported by the Houston data. Firstly, the data gave no indication that townhomes were inherently less valuable than single family homes, and secondly the data appeared to suggest that townhome builders were able to target lower price points than single family homes, but that developers did not always do so. The more accurate description may be townhomes can be more affordable than single family, but other features such as home size drive value much more than yard size, and townhome construction itself does not necessarily produce units any more affordable than single family construction.

There are some important limitations to this study. The largest issue is the use of appraisal values instead of sales prices. Appraisal values are an estimated proxy for actual value, but they are not real values the way that sales prices are. Appraisals are created based in large part on housing characteristics, so using multivariate regression with appraisal values and some of the data used to create those appraisals bears some inherent risk of endogeneity. Another limitation of this study is that it does not take geography into account beyond the basic requirement of being in Houston proper. Neighborhood level conditions could and likely do determine townhome's relative prices to single family homes, because builders could potentially concentrate luxury units in ‘hot’ areas while building more affordably in other places.

This study suggests that townhome builders have some flexibility to adjust their price points to meet market demand, but it does not show how building is concentrated or dispersed in certain areas. A future study could greatly contribute to an understanding of the effects of townhomes in Houston by spatially mapping construction and measuring their impacts on areas with high construction volumes.

If Houston policymakers wish to encourage affordability through denser townhome development, they ought to consider lowering the minimum lot size further. Although lot size itself was not associated with noticeable affordability gains, lowering it would allow developers to build smaller units that would likely sell for a lower price. This would give developers flexibility to build cheaper housing, but the study suggests they would not choose to do so in a strong market. A novel approach to encouraging affordability may be to include a maximum square footage size requirement on a portion of townhomes in a given development. The price of the smaller units could still be left unregulated, but the trends in value per square foot suggest they would naturally be relatively affordable. Such a requirement would likely fail to supply houses to very low income populations, but it could be an option for supplying middle and possibly lower middle class people with new housing options.

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